

Sicafodiidae, fam. nov. for *Sicafodia stylos*, gen. nov., sp. nov., from the marine bathyal of south-eastern Australia (Crustacea: Amphipoda: Gammaridea)

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Abstract

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A new genus and species, *Sicafodia stylos*, is described from bathyal depths (400–1277 m) off south-eastern Australia. Following a discussion of its possible placement in existing families, a new family, Sicafodiidae, a potential sister taxon to the Pardaliscidae, is established. The new species is characterised by the extreme elongation of its conically bundled mouthparts including the inner plate of the maxillipeds, a completely smooth body, short, broadly rounded coxal plates, slender, simple but strongly dissimilar gnathopods and elongate pereopods. An analysis of the functional morphology of the mouthparts, including muscles in the upper lip and epistome, indicates that *Sicafodia stylos* feeds by piercing its prey and sucking up macerated/liquefied food. The actual food items are not known.

Keywords

Crustacea, Amphipoda, Sicafodiidae, fam. nov., *Sicafodia*, deep-sea, Australia

Introduction

The new species described below was collected as part of the South-Eastern Australian Slopes Program of Museum Victoria and the Victorian Institute of Marine Sciences. The program commenced in 1986 with sampling at bathyal depths (approximately 200 to 2900 metres) off southern New South Wales, Bass Strait and eastern Tasmania, followed by a similar sampling program in 1988. A highly diverse and novel fauna of Peracarida was brought to light. A preliminary analysis of the composition and diversity of Isopoda and comments on other groups of Crustacea, together with environmental data from this stretch of continental margin towards the Tasman Sea, was provided by Poore et al. (1994).

The length of specimens was measured from the tip of the rostrum along the dorsal curvature to the tip of the telson. The specimens are deposited in the collections of Museum Victoria, Melbourne, Australia.

Classification of the new species

Using Barnard and Karaman's (1991) key to families, the new species falls among Ochlesidae (as Ochlesinae in their broad concept of the Iphimediidae) and Lafystiidae on account of its lack of a mandibular molar and the reduced number of articles (three) in the maxillipedal palp. Using the key in Coleman and

Barnard (1991) the species keys out in the vicinity of Lafystiidae and Laphystiopsidae on account of its simple gnathopod 1, rounded, non-elongate coxae 1–3, and lack of mandibular raker setae. None of these characters is unique to those families. Bousfield (1983), Barnard and Karaman (1991) and, by implication, Coleman and Barnard (1991) assumed that at least Lafystiidae, and for the last two works possibly also Laphystiopsidae, are basically related to the iphimedioids. A recent phylogenetic analysis of amphipod families (Berge et al., 2000), however, places those two families in separate clades, neither with iphimedioid families. The Lafystiidae do, however, show some similarities with the iphimedioids (see discussion below) in the elongate, acuminate coxa 4 and short, robust pereopods with curved dactyli, the conically pointed, but weakly modified mouthparts, simple gnathopod 1 and subchelate gnathopod 2. For these reasons, the family is implicitly included in the general discussion of the iphimedioids below. Laphystiopsidae have simple, identical gnathopods similar to, but smaller than, pereopods 3 and 4, and quadrately bundled unmodified mouthparts. Laphystiopsidae bear little resemblance to the new species and will not be discussed further. For Ochlesidae see discussion below.

The most immediately obvious characteristics of *Sicafodia stylos* is the extreme elongation and acuteness of the downward, backward pointing mouthpart bundle. Conically bundled, pointed mouthparts are uncommon in gammaridean

Amphipoda. They are found primarily in the conicostomatid group of genera in the Lysianassoidea (see Lowry and Stoddart, 1983), in monotypic Didymocheliidae, in the iphemedioids, and in two genera of the Pardaliscidae.

Sicafodia stylos clearly does not belong in the Lysianassoidea, species of which have a characteristic body shape and an elongate ischium and mitten shaped propodus of gnathopod 2. Whilst there are some similarity in the mouthparts, notably in the enlarged, folded outer plate and the elongate inner plate of the maxillipeds in some conicostomatid genera, these similarities must have been independently derived to serve a similar function (see section on mouthpart function below).

The three known species of *Didymochelia* (see Bellan-Santini and Ledoyer, 1986, Lowry and Stoddart, 1995) have moderately conical mouthpart bundles, but little or no modification of mouthparts with regard to elongation or reductions. Furthermore, didymocheliids have gnathopods 1 and 2 chelate, pereopods 3-7 short and strong with curved dactyli, uropod 3 reduced to a stubby ramus only, and the telson shorter than wide, entire. *Sicafodia stylos* cannot be referred to the Didymocheliidae.

Coleman and Barnard (1991) divided the non-eusiroid iphemedioids into six families: Iphemediidae, Ochlesidae, Acanthonotozomatidae, Acanthonotozomellidae, Dikwidae and Odiidae. Berge et al. (1999) merged Ochlesidae and Odiidae under the former name. Species in these families have conically bundled, more or less elongate mouthparts with a variety of strong or less strong reductions. The strongest elongations and reductions are found in species of Ochlesidae s.s. None, however, exhibits the extremes found in *Sicafodia stylos*. Iphemedioids have moderately compressed bodies (broadly rounded dorsally in *S. stylos*), dorsal spines and/or carina (smooth), one or more of coxae 1-4 elongate, tapering and acuminate, or elongate and oddly shaped (Ochlesidae s.s.) (approximately as long as broad, non-tapering, apex broad, rounded), one or more of pleonal sideplates 1-3 with acute posteroventral corner and often with additional cusp on posterior margin of sideplate 3 (broadly rounded, no cusps), pereopods 3-7 short, strong, 'clinging' with strong, curved dactylus (slender, elongate, dactylus slender, nearly straight). Some iphemedioid families have simple, similar or dissimilar gnathopods 1 and 2; in some families both gnathopods are subchelate or chelate; in others a combination; while they are carpo- or merchelate in Ochlesidae s.s. Simple gnathopods occur in many gammaridean families. Thus, there are no characters that unequivocally place *S. stylos* within the iphemedioids, while its smooth dorsum, elongate, slender pereopods 3-7 and short, rounded coxae 1-4 in particular preclude such an allocation.

Sicafodia stylos shares with Pardaliscidae a smooth body, short simple coxae 1-4, simple gnathopods 1-2, slender pereopods 3-7 (5 and 7 assumed), and lanceolate uropodal rami. However, the gnathopods in *S. stylos* are highly dissimilar, whereas in the Pardaliscidae they are generally of similar shape and size. Pardaliscids normally have quadrately bundled mouthparts, with broad molar incisors and strongly reduced (or absent) inner plate of the maxillipeds (prominent and much

elongate in *S. stylos*). The exceptions to quadrate mouthparts in pardaliscids are *Halicella* Schellenberg (monotypic) and *Rhynohalicella* Karaman (monotypic), in both of which mouthparts form a small downward or forward pointed cone respectively, but the structure and reductions of individual mouthparts differ significantly from those of *S. stylos*.

Conical bundling with some elongations and reductions in mouthparts clearly has been independently derived in several non-related families, and therefore does not in itself place *S. stylos* within any of the groups discussed. Disregarding the mouthparts, *S. stylos* appears to be closer to the Pardaliscidae than to any of the other families mentioned. The prominent inner plate of the maxillipeds and the dissimilar gnathopods would appear to preclude the inclusion of the new species in that family, although it could be conceived as representing a separate subfamily taxon in the Pardaliscidae with extremely apomorphic mouthparts, but having retained a plesiomorphic inner plate of the maxillipeds, reduced or lost in all other members of the family (the sister clade). However, because of the lack of males, and lack of complete antennae 1 and 2 and pereopods 5 and 7 in all specimens, which might provide firmer clues to the placement of this species, I hesitate to place *Sicafodia stylos* in the Pardaliscidae. Instead, I refer it to a new family, Sicafodiidae, a potential sister taxon of Pardaliscidae.

Sicafodiidae fam. nov.

Diagnosis. Body broad, smooth; cuticle smooth. Cephalon short with well developed rostrum. Pereonite 1 enlarged, partly overlapping cephalon. Pleonal sideplates broadly rounded. Primary flagellum of antennae multiarticulate (not confirmed for antenna 2), accessory flagellum present, 1-articulate, antenna 1 with calynophore commencing on first flagellar article. Coxal plates 1-4 apically rounded, barely longer than broad, overlapping, forming an even ventral curve, coxa 4 barely excavate posteriorly. Mouthparts elongate, grouped into sharply pointed downward-backward pointing cone. Upper lip apically notched. Mandibles without molar and spine row, with 3-articulate palp, both mandibles with rod-shaped lacinia mobilis. Lower lip with mandibular lobes, inner lobes absent. Maxilla 1 without palp, inner plate digitiform, outer plate with 9 distal spine-like setae. Maxilla 2 plates slender, with apical and subapical setae only. Maxilliped with 3-articulate palp, outer and inner plates of subequal length. Gnathopods 1 and 2 simple, strongly dissimilar. Pereopods 3-7 slender, dactyls slender, nearly straight, pereopods 5-7 with article 2 expanded. Urosomites free. Uropods with full complement of slender, lanceolate rami, peduncle of uropod 3 short. Telson short, laminate, apically incised. Coxal gills simple sacks, on pereopods 2-7. Oostegites on pereopods 2-5, 2-4 broad, sparsely setose, 5 linear.

Type genus. *Sicafodia* gen. nov.

***Sicafodia* gen. nov.**

Type and only species. *Sicafodia stylos* sp. nov.

Diagnosis. With the characters of the family.

Etymology. The name of the genus is derived from Latin, *sica*, dagger, and *fodio*, to stab, hence 'the one that stabs with a dagger', alluding to the shape of the mouthpart bundle. Feminine.

***Sicafodia stylos* sp. nov.**

Figures 1–4

Material examined. Holotype. Female with developing ovaries, 3.7 mm. Australia, eastern Tasmania, off Freycinet Peninsula, 41° 57.50'S, 148° 37.90'E, 400 m, coarse biogenic rubble, mud, WHOI epibenthic sled, M.F. Gomon et al., RV *Franklin*, 27 Jul 1986 (stn SLOPE-48), NMV J23915 (condition: antennae, some pereopods and tip of some uropods broken).

Paratypes (5 specimens, all from Australia). Same data as holotype, NMV J23916 (female A, with apparent traces of broken oostegites; condition: antennae and most pereopods and uropods broken, telson missing). Eastern slope of Bass Strait, 38° 21.90'S, 149° 20.00'E, 1000 m, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 23 July 1986 (stn SLOPE-32), NMV J23917 (female B, with fully developed oostegites, 4.6 mm; condition: antennae, some pereopods and uropods broken), NMV J23918 (female C, with fully developed oostegites; condition: half specimen, everything posterior to pereonite 6 missing, antennae and most pereopods broken), NMV J23919 (female D, with fully developed oostegites; condition: half specimen, everything posterior to pereonite 7 missing, antennae and most pereopods broken). Eastern Bass Strait slope, 67 km S of Point Hicks, 38° 23.78'S, 149° 17.02'E, 1119–1277 m, fine mud, WHOI epibenthic sled, G.C.B. Poore et al., RV *Franklin*, 25 Oct 1988 (stn SLOPE-67), NMV J23920 (1 specimen, condition: antennae, all pereopods and most of uropods broken).

Description. *Cephalon* depth approximately 2.5 times mid-lateral length. In lateral view cephalon tapering towards right angled ventral corner. Ocular lobes broadly rounded, continuing in nearly straight line to ventral corner. Eyes absent. *Rostrum* about as long as deep in lateral view, apex rounded triangular, approximately half length of non-rostral part of cephalon, ventrally forming a narrow angle with elongate, convex frons part of cephalon. *Epistome* short, unproduced.

Pereonite 1 as long as its anterior depth, as long as 2 and 3 combined. *Pleosome* dorsal length equalling combined length of pereonites 2–7, pleonites of equal length.

Coxal plates 1–4 with smoothly rounded ventral margin; plates 1–3 of subequal length when flattened, (appear to increase in length from 1 to 3 in Fig. 1 habitus, due to 1 and 2 curving slightly inwards), of rounded rectangular shape but increasing in width from 1 to 3; coxa 1 length:width 1.25, coxa 2 length:width 1.20, coxa 3 length:width 1.0, coxa 4 length:width 0.70, with rounded angular posterior projection and weak concavity posterior to projection; coxa 5 with lobes equally deep, anterior lobe wider, evenly rounded, posterior lobe rounded rectangular; coxa 6 similar to 5, but posterior lobe approximately third deeper than anterior lobe; coxa 7 an evenly rounded semicircle. *Pleonal sideplates* with smooth margin; plate 1 with weakly angular apex, 2 and 3 rounded.

Antenna 1, peduncular article 1 as long as 2 and 3 combined, approximately 10% longer than lateral width, articles 2 and 3 of subequal length, both somewhat telescoped into preceding article, article 3 with lateral apical margin extended beyond

insertion of accessory flagellum; *accessory flagellum* approximately half length of flagellar article 1, distally tapering, with 1 apical and 1 subapical setae; article 1 of flagellum approximately two-fifths as wide as long, with single-field callinophore composed of 4–5 irregular rows of aesthetascs, article 2 and 3 with 2 distal rows of similar aesthetascs. *Antenna* 2 with broad, apically pointed antennal cone; peduncular article 4 approximately twice as long as wide, reaching to apex of flagellar article 1 of antenna 1. (Antennae otherwise broken in all specimens, but the shape of the proximal parts known suggests that the flagellum of both antennae is simple, multiarticulate). *Upper lip* approximately 2.5 times longer than wide at base (anterior view), narrowing in middle, tapering towards bilobed apex, apical notch forming a narrow angle. *Mandibles* styliform distal to insertion of palp, reaching to apex of upper lip; left mandible with irregularly notched apex, lacinia mobilis a long slender rod terminating in strongly oblique cutting edge with 6 or 7 small denticles; right mandible with 3 blunt teeth apically, lacinia mobilis quarter to half length of left lacinia mobilis, with bifid apex; strong palp inserted in proximal third of mandibular body, reaching slightly beyond apex of mandible, article 1 as long as broad, article 2 approximately 4 times longer than broad with 2–3 distal setae, article 3 approximately three-quarters length of 2, with up to 4 setae on posterior margin and approximately 4 apical setae, lateral surface partly covered with fine setules. *Lower lip* with styliform lobes, lobes finely setose apically not quite reaching apex of mandibles; mandibular lobes short, slender, pointing directly backwards. *Maxilla* 1 outer plate approximately 11 times longer than greatest width; distal 9 spine-like setae falling into three groups: 2 apical setae (one coarsely serrate along entire length, one finely serrate in distal quarter), 5 setae closely set on strongly oblique margin (regularly denticulate in distal half), 2 poorly articulating, flattened more proximal setae closely adpressed to medial surface of plate, coarsely and irregularly serrate along entire margin; inner plate approximately third length of outer, slender, cylindrical, tapering towards rounded apex, without setae. *Maxilla* 2 outer plate approximately 9 times longer than greatest width, with tuft of approximately 6 unequally long apical setae; inner plate approximately 80% length of outer, with 4 apical simple setae and 3 short, subapical medial bi- or trifid setae. *Maxilliped* palp article 1 ovoid, approximately 50% longer than wide, article 2 approximately 80% length of 1, of similar shape, article 3 as long as 1 and 2 combined, third width of 2, approximately 9 times longer than wide with 3 or 4 groups of 2 or 3 setae on midlateral surface and tufts of apical and subapical setae; outer plates broad in proximal third, tapering towards truncate apex, apex with row of at least 8 blunt, rod-like setae evenly decreasing in length from medial to penultimate lateral seta, lateralmost seta stouter than the rest, approximately as long as medialmost one, curved mediad, with denticles in distal quarter, (because of the natural forward folding of outer plates around remaining mouthparts, Fig. 2C mxp dv, the lateralmost, denticulate seta, Fig. 2A mxp op, is functionally in a medial position, cf. above); inner plates nearly as long as outer plates, each plate slender with nearly parallel margins, terminating in bluntly pointed apex with what appears to be glandular tissue in terminal part (Fig. 2C mxp ip), plates

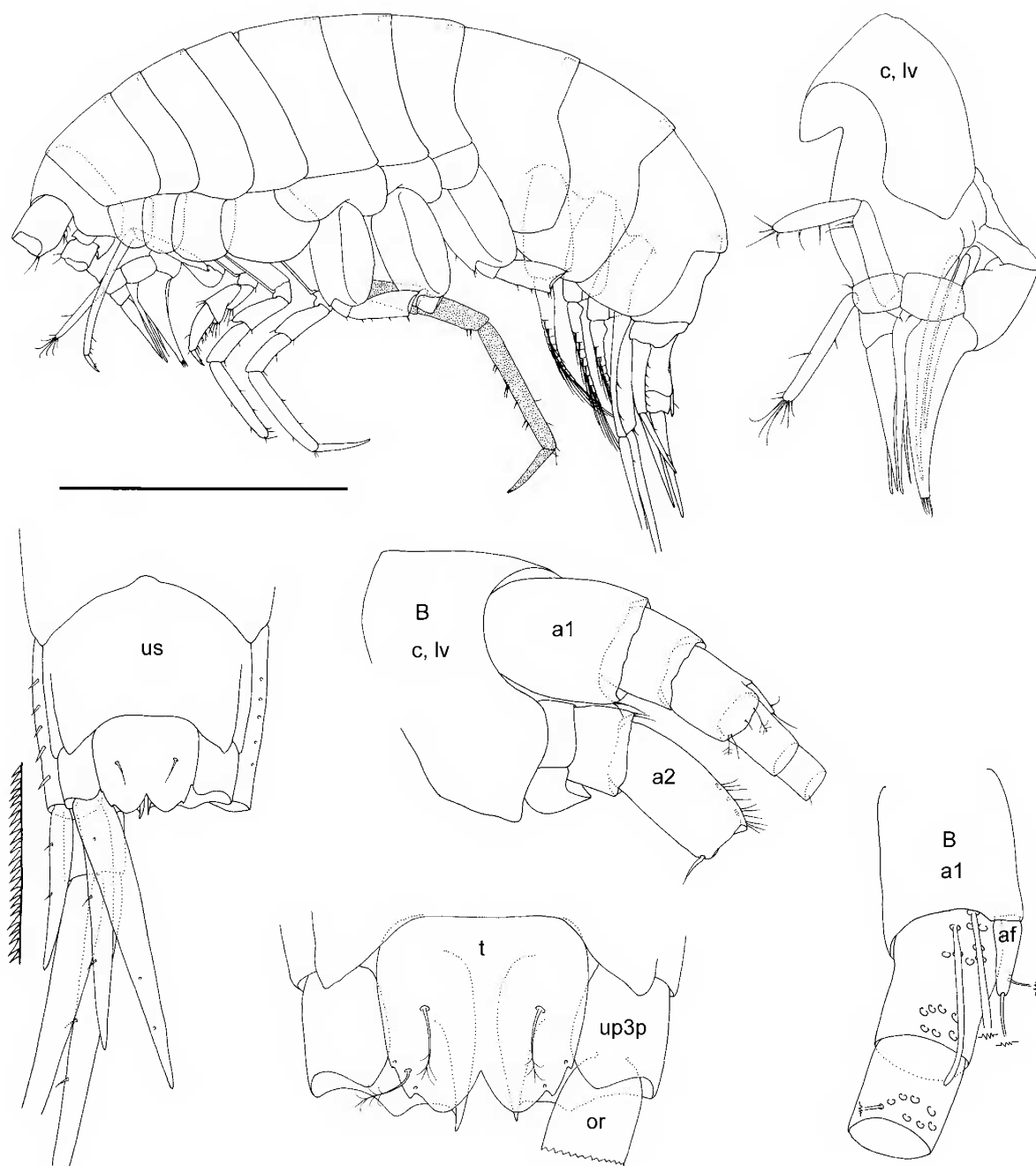


Figure 1. *Sicafodia stylos*, gen. nov, sp. nov. Holotype, except B, paratype, female B (NMV J23917). a1, antenna 1; a2, antenna 2; af, accessory flagellum; c, head; lv, lateral view; or, outer ramus up3; t, telson; up3p, uropod 3 peduncle; us, urosome. Habitus scale bar: 1 mm.

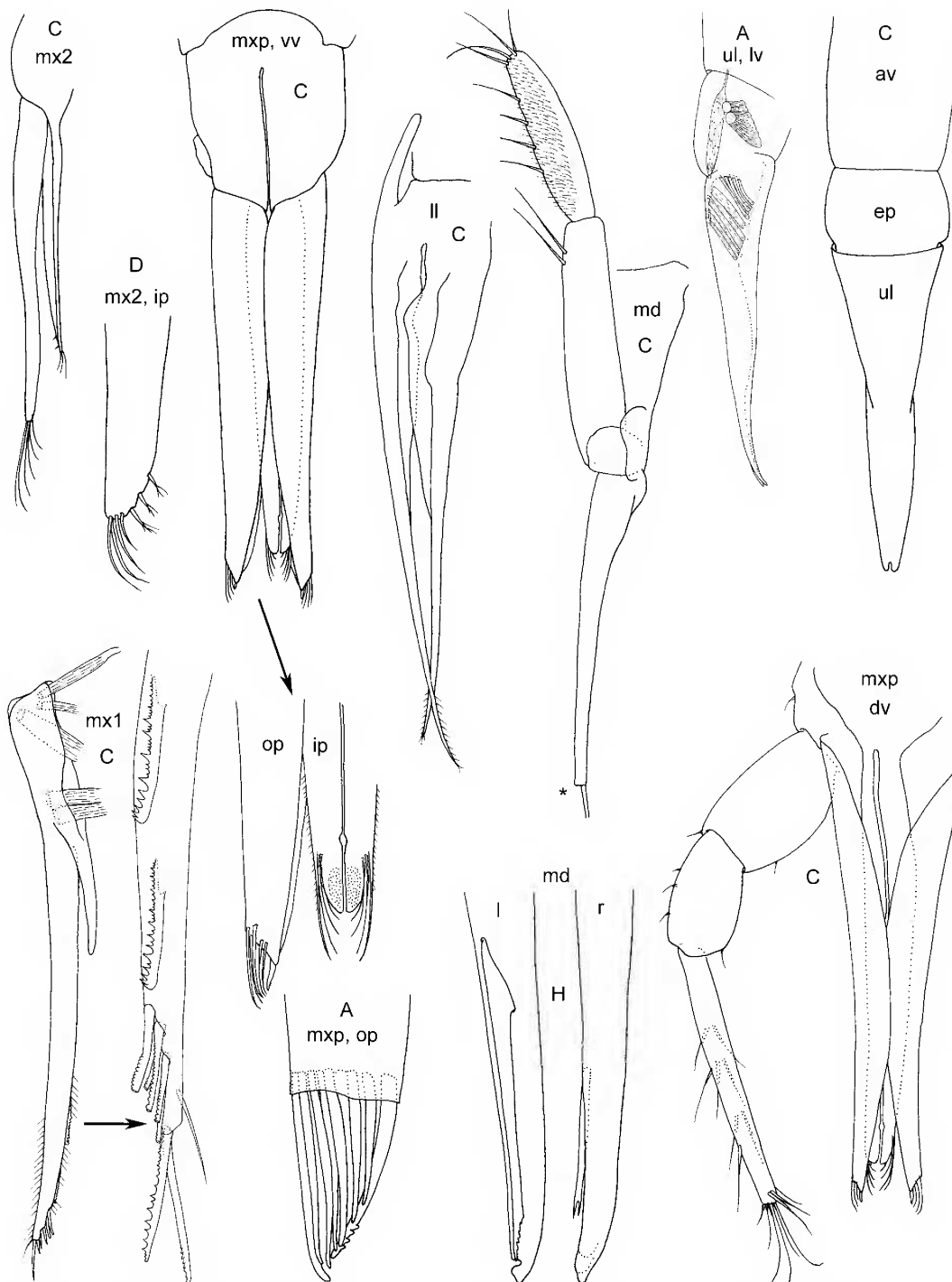


Figure 2. *Sicafoadia stylos*, gen. nov., sp. nov. A, paratype, female A (NMV J23916); C, paratype, female C (NMV J23918); D, paratype, female D (NMV J23919); H, holotype. av, anterior view; dv, dorsal view; ep, epistome; ip, inner plate; l, left; ll, lower lip; l, r md, mandible; mx 1, 2, maxilla 1, 2; mxp, maxilliped; op, outer plate; r, right; ul, upper lip; vv, ventral view; asterisk: tip of mandible and lacinia mobilis broken.

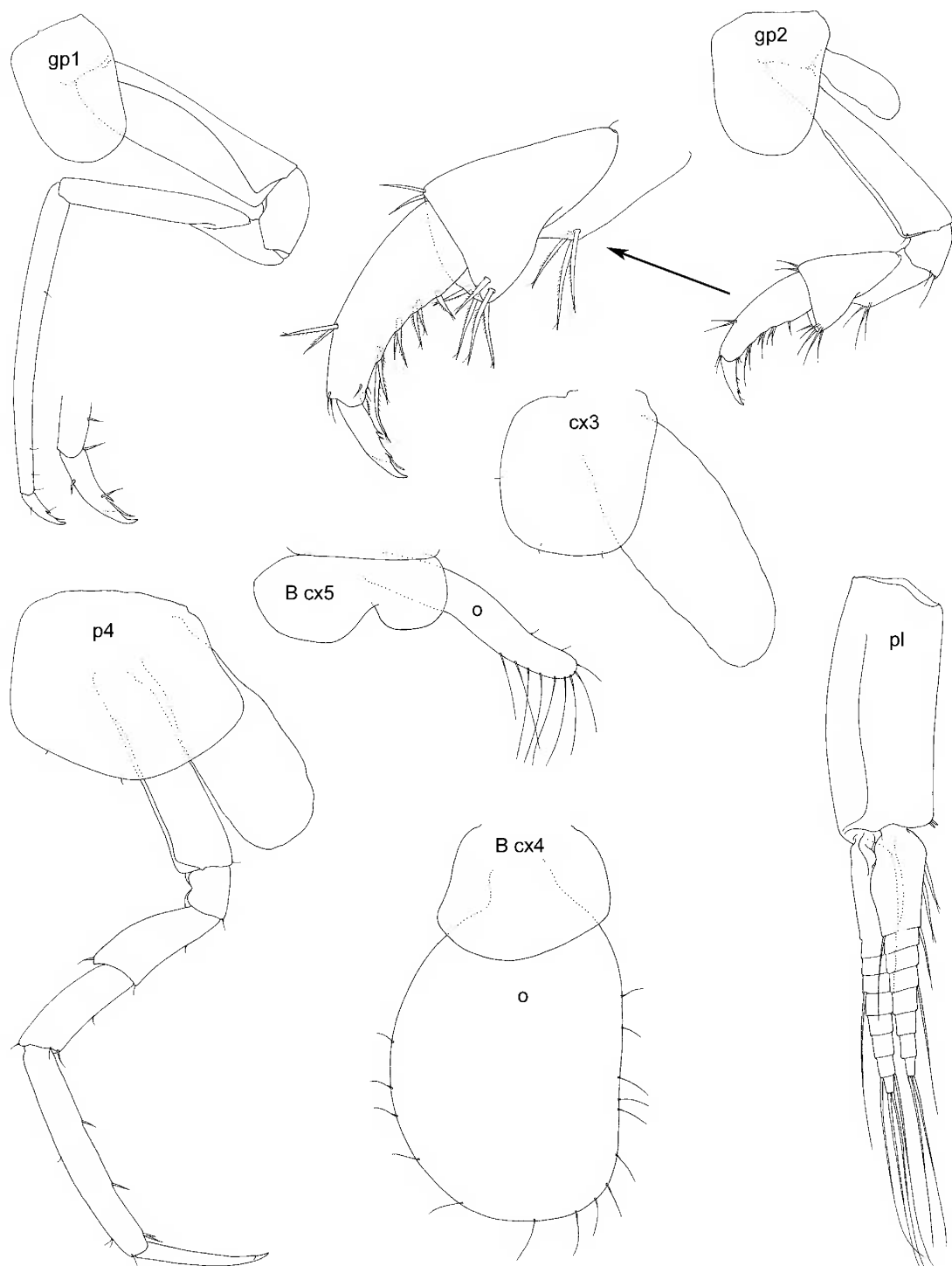


Figure 3. *Sicafoadia stylos*, gen. nov., sp. nov. Holotype, except B, paratype, female B (NMV J23917). cx, coxa; gp, gnathopod; o, oostegite; p, pereopod; pl, pleopod.

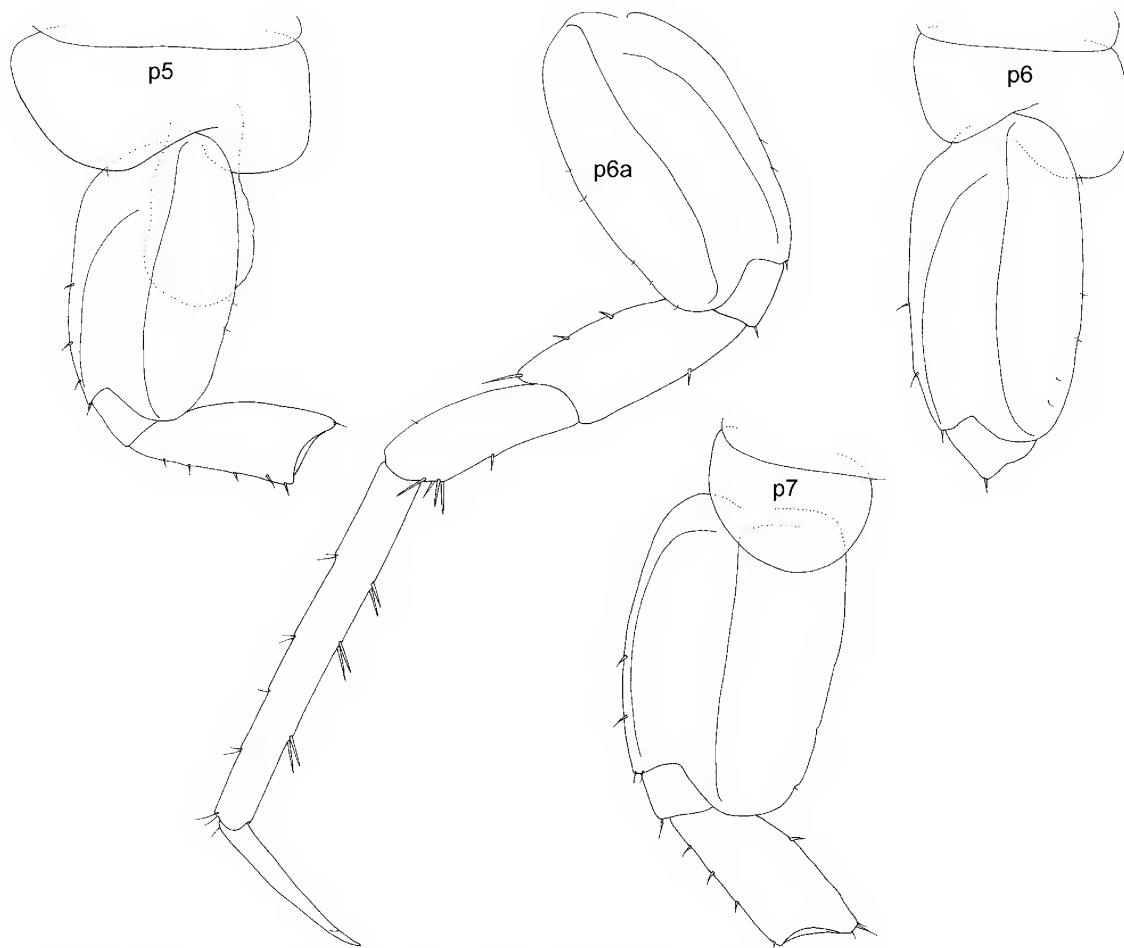


Figure 4. *Sicafodia stylos*, gen. nov., sp. nov. Holotype. p5–7, left pereopods 5–7; p6a, right pereopod 6.

with small opposing notch in medial margin proximal to 'gland', each plate laterally, between notch and 'gland', with tuft of 4 or 5 inward curving setae decreasing in length from lateral to medial.

Gnathopod 1 basis approximately 4 times longer than broad, as long as merus and carpus combined, with anterior longitudinal concavity to receive article 5 when fully folded back; ischium approximately twice as long as lateral width; merus triangular, anteriorly pointed, approximately as long as ischium, with carpus inserted on anterior margin; carpus slender, twice as long as merus, with parallel margins, approximately 6 times longer than wide, unarmed; propodus approximately 65% longer than carpus, 12 times longer than broad at base, slightly curved and faintly tapering distally, with a few short posterior setae; dactylus weakly curved, approximately sixth length of propodus, with posterior tooth near base of stout, curved unguis, 1 straight, simple seta level with tooth and 2 curved, blunt, simple setae at posterior base of and adpressed to unguis.

Gnathopod 2 little more than half the length of 1, without elongate elements; carpus approximately 80% the combined length of ischium and merus, triangular, approximately 50% longer than lateral distal width, posterodistal lobe setiferous, not projecting along propodus; propodus approximately 10% longer than carpus, moderately curved, tapering distally, with 4 or 5 posterior groups of stiff, pectinate setae, anterior margin with group of similar setae at distal two-thirds; dactylus half length of propodus, similar to that of gnathopod 1 but with 2 small midposterior teeth.

Pereopods 3 and *4* similar, slender, approximately 4 times longer than respective coxal plates; merus and carpus subequal in length, combined as long as basis; propodus twice as long as carpus; merus, carpus and propodus with a few posterior and anterior small setae, propodus with small posterodistal robust seta; dactylus half length of propodus, nearly straight, length approximately eight times width at base. Pereopods 5–7 apparently alike (pereopod 6 the only entire limb known, hence

relative lengths of 5–7 not known, but probably of subequal length), with posteriorly expanded distally rounded basis, posterior margin smooth with scattered setules, with midlateral and anterolateral ridges; at least pereopod 6 approximately third longer than pereopods 3 and 4, but otherwise of similar shape and proportions, carpus posterodistally and propodus posteriorly with groups of slender robust setae.

Pleopods strong, alike; peduncle approximately twice as long as wide (posterior view), with 2 mediobasal coupling hooks; subequal rami as long as peduncle, proximal part of rami with opposing surfaces excavate, outer ramus with posterior proximal locking projection.

Urosomite 1 as long as 2 and 3 combined; urosomite 2 dorsal length approximately quarter that of elongate 3; urosomite 3 dorsally flattened to slightly concave in transverse section. *Uropods* 1 and 2, peduncles with lateral robust setae; uropod 1 overreaching 2 and outer ramus of 3, (tip of uropod 1 rami broken in all specimens, but proportions between rami and peduncle probably approximating those in uropod 2); uropod 2 shorter than 1, reaching nearly to tip of outer ramus of 3, outer ramus as long as peduncle, inner ramus approximately 40% longer than outer; uropod 3 biramous (inner ramus lost in all specimens, but presence indicated by socket and musculature), peduncle as long as wide, reaching to tip of telson, outer ramus approximately 5 times longer than peduncle; rami of all uropods slender lanceolate, without terminal setae(e), but apparently all with a few small lateromarginal setae, margins finely serrate. *Telson* approximately 10% broader than long, reaching to distal margin of peduncle of uropod 3, quarter cleft in open V-shape; lobes rounded, each with 2 distolateral marginal teeth, 2 or 3 small pappose setae level with teeth and 1 long similar seta at mid-surface.

Size. Largest female, 4.7 mm. Male not known.

Etymology. The species name is derived from the Latin *stylus* meaning pointed instrument or pen, and *os* meaning mouth, alluding to the long, pointed mandibles. Noun in apposition.

Distribution. South-eastern Australia, 400–1277 m depth.

Function of the mouthparts

Conically bundled, elongate, pointed mouthparts are frequently referred to as having piercing and possibly sucking functions. In most cases the piercing action can be readily understood, whereas the subsequent transport of food (particles, macerated tissue, body fluids) has not been studied in detail. Dahl (1964) discussed the probable function of the mouthparts and adjacent parts of the digestive tract in *Acidostoma neglecta* Dahl, 1964 (Lysianassoidea; ectoparasite on sea anemones, Vader, 1983). He found that muscles in the oesophagus and the anterior part of the stomach may create the necessary negative pressure to lift up food through the narrow passageways of the conically bundled mouthparts.

In spite of many differences in mouthpart details, the general outline of the bundle is quite similar between *Acidostoma* and *Sicafodia*. *Sicafodia* also seems to possess the two prerequisites necessary for sucking up food through the mouth cone, viz., a tight lumen, and a sucking mechanism. When the

maxillipeds are brought fully forward, a tight funnel may be created between the forward-inward folded outer plates and the elongate upper lip (as in *Acidostoma*); the equally elongate inner plates of the maxillipeds will help seal the funnel posteriorly. Once the apex of the mouthpart cone is embedded in the food item tissue and a tight funnel has been established, a sucking device may be found in the proximal part of the upper lip, where obliquely set transverse muscles (Fig. 2A ul, lv) will, on contraction, pull the soft-walled posterior surface of the upper lip forward thus drawing liquid or semi-liquid food upward through the funnel. The obliquely transverse muscles in the epistome may have a similar function, bringing food closer to the oesophagus. Additional mechanisms, like those described by Dahl (1964), have not been observed but may be present to finally lift food into the stomach.

Following the initial piercing by the mandibles, the apical and subapical spine-like setae located on the maxillipedal outer plate and the outer plate of maxilla 1 may help in extending the wound and shredding the tissue. If the tips of the maxillipedal inner plates are indeed glanduliferous as suggested in the description, such glands may release proteolytic enzymes into the wound and thus help speeding up the maceration process before suction transport.

The actual food items of *Sicafodia stylos* are not known. However, the lack of grasping gnathopods or strongly dactylate, clinging pereopods suggest that *Sicafodia* is not a fish parasite. In view of its slender epibenthic/pelagic pereopods 3–7 and the strongly developed pleosome the species is probably a roaming predator on some group or groups of sessile or sluggish benthic or epibenthic invertebrates.

Acknowledgments

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